

Executive Summary

Site Characterization Meets Key Milestone; Waste Acceptance Issues Remain Open

Introduction

Fiscal Year 1998 was a pivotal year in the history of the Office of Civilian Radioactive Waste Management (OCRWM), and one of the most productive. By the end of the year, all OCRWM commitments in the Secretary's performance agreement with the President for Fiscal Year 1998 had been met.

Dominating the year was the work of completing the viability assessment for the Yucca Mountain site in Nevada, which we are studying as a potential geologic repository for spent nuclear fuel and high-level radioactive waste. The viability assessment documented what we had learned from 15 years of studies, and it explained how we plan to proceed.

While the viability assessment does not constitute a decision on the suitability of the Yucca Mountain site for repository development, it clearly identifies what we believe are the remaining key uncertainties about repository system performance and explains the work required to reduce them. The document thus serves as a valuable tool for managing the work ahead. It also provides a common framework for all parties to the Program. Not only Congress and the Administration, but regulatory, oversight, and stakeholder organizations can examine the issues that we believe must be resolved and evaluate our approach to them.

As we developed the viability assessment, we continued to benefit from independent peer review and expert elicitation; the recommendations of the Nuclear Waste Technical Review Board, which

oversees the technical and scientific aspects of our work; and interactions with the Nuclear Regulatory Commission (NRC), which is responsible for repository licensing. Recognition continued to grow among parties outside the Program that a repository will serve not only the needs of commercial utilities for disposal of their spent nuclear fuel, but the needs of the Federal Government for safe disposal of the nuclear materials it manages.

Reduced funding and cuts in personnel led us to defer further transportation planning and planning for acquisition of waste acceptance and transportation services. It also led us to restructure our organization to focus our resources primarily on preparing the work products needed to meet statutory requirements: issuance for public comment, in 1999, of a draft environmental impact statement that will examine the potential impacts of a repository at Yucca Mountain; a decision, in 2001, by the Secretary on whether to recommend the site to the President for development as a repository; and, if the site is recommended and approved, submittal, in 2002, of a license application to the NRC.

Yucca Mountain Site Characterization Project

Completing the viability assessment for a repository at Yucca Mountain

In 1996, we announced that we would prepare a viability assessment of the Yucca Mountain site so that policy makers could better assess our

progress. In its 1997 Energy and Water Development Appropriations Act, Congress endorsed this plan by making it a statutory requirement. A multi-volume document, the *Viability Assessment of a Repository at Yucca Mountain* includes (1) a site description, (2) a reference design for the repository and waste package, (3) a total system performance assessment, (4) a plan and cost estimate for the work remaining to complete a license application, and (5) an estimate of the cost to construct, operate, monitor, and close a repository based on the reference design. At the end of the fiscal year, the viability assessment was under review within the Department of Energy (DOE). On December 18, 1998, the Secretary of Energy submitted it to the President and to Congress. It was distributed to the Governor and Governor-elect of Nevada, the Nevada Legislature, the affected units of local government, key government agencies, other organizations with oversight responsibility for the Yucca Mountain Project, and the media. The viability assessment and companion and supporting documents were made available to the public on the OCRWM Web site.

Based on the results of the viability assessment, DOE believes that work should proceed to support a decision in 2001 on whether to recommend the Yucca Mountain site to the President for development as a repository. An important element of site recommendation is DOE's ability to demonstrate that a repository designed for and built at Yucca Mountain would protect public health and safety and the environment for thousands of years. The viability assessment identifies the seepage of moisture into repository tunnels, termed *drifts*, and onto waste packages as the most significant factor affecting waste package degradation and release of radionuclides. It forecasts the range of likely radiation doses to nearby residents over thousands of years to be very low. The cost of completing the work necessary to prepare and support a license application is estimated to be \$1.1 billion, with the

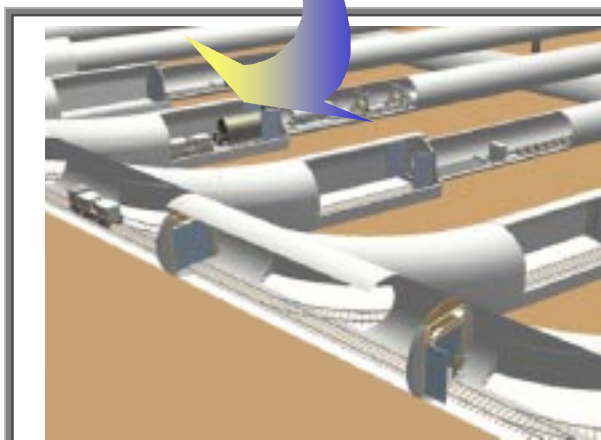
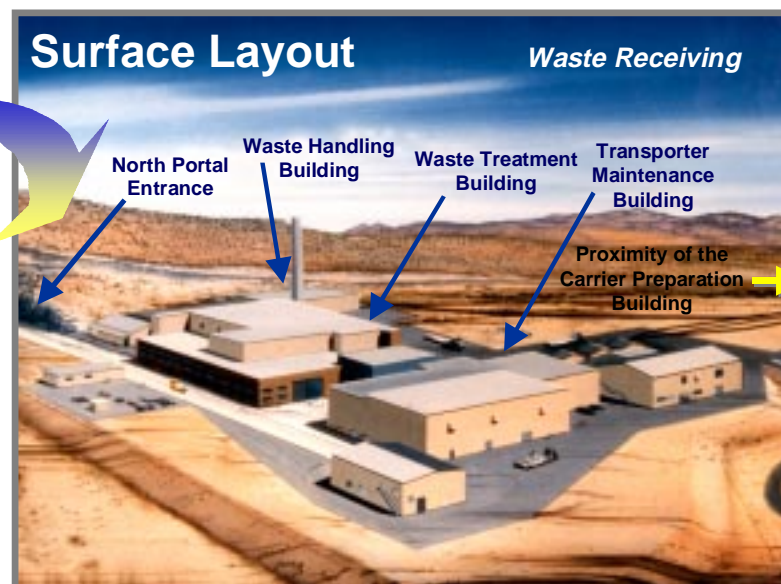
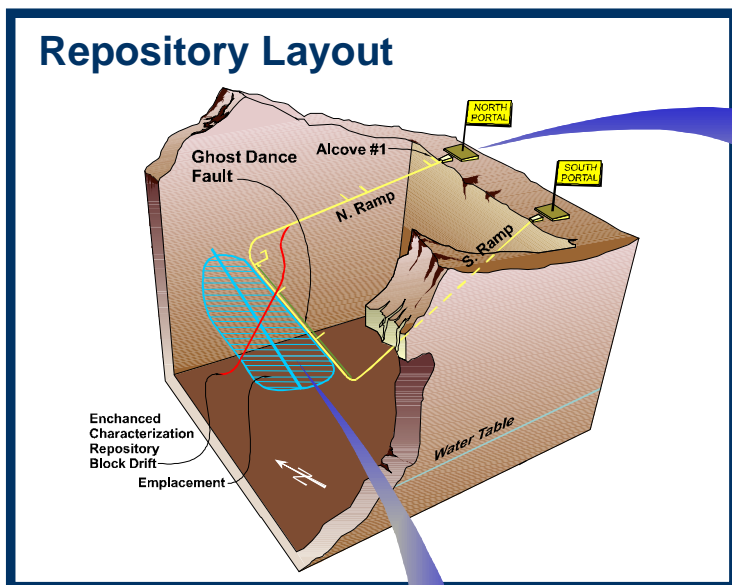
total cost of repository development ranging from \$16.3 to \$19.8 billion, depending on the length of the monitoring period.

Reports accompanying the viability assessment include a new total system life-cycle cost (TSLCC) analysis. It reflects design concepts used in the viability assessment and provides a comprehensive cost estimate for disposal of all wastes projected through 2035. Besides including all costs identified in the viability assessment, the TSLCC includes historical costs, and the costs of transportation, construction of a rail spur in Nevada, and certain institutional, program integration, and management cost categories not included in the viability assessment. The analysis projects a total future cost to complete the Civilian Radioactive Waste Management Program, through repository closure in 2116, of \$36.6 billion in constant 1998 dollars.

The TSLCC served as the basis of another report issued with the viability assessment: OCRWM's fee adequacy assessment, which analyzes whether the fee paid by commercial utilities into the Nuclear Waste Fund is likely to cover all costs of disposing of commercial spent nuclear fuel. The assessment considered a reasonable range of uncertainties in projecting what the Fund's balance would be at the end of the Program's life and concluded that there is no need at this time to change the fee. The fee adequacy assessment does not address disposal fees for DOE-managed nuclear materials, which are paid through congressional appropriations.

The work ahead

As intended, preparing each volume of the viability assessment advanced our work substantially by consolidating and integrating a wealth of information, clarifying critical issues, and prioritizing the work ahead. That work entails drafting an environmental impact statement and preparing the other information needed to inform a



Subsurface Layout

Waste Emplacement

The proposed repository will include approximately 100 placement tunnels (73 miles of tunnels), each 0.62 miles in length; approximately 100 waste packages will be emplaced in each tunnel.

Viability assessment reference design concept

Secretarial decision on site recommendation, and preparing a license application.

This product-oriented approach marks a shift in focus away from scientific inquiries conducted on the frontiers of knowledge and toward efforts to reduce the key uncertainties that remain about the natural features of the Yucca Mountain site and how they would perform in concert with the engineered barriers of a repository system. To reduce uncertainties we are (1) further refining performance assessment modeling, (2) concluding many site investigations, while managing longer-term studies, (3) testing waste package materials, (4) evaluating alternative repository and waste package designs and adopting and documenting the next generation of reference design, and (5) ensuring the defensibility and traceability of work products and full compliance with quality assurance.

Performance assessment

The determination of site suitability will rely in large measure on an assessment of how the total repository system could reasonably be expected to perform; that is, how well the natural features of the site acting in concert with engineered barriers would isolate radionuclides and retard their transport to the accessible environment. Total system performance assessment employs numerical modeling to forecast this performance under a range of conditions, over thousands of years.

As part of the viability assessment, we conducted a total system performance assessment of the proposed repository system based on the latest reference design and information about the site. Building on total system performance assessments conducted in 1991, 1993, and 1995, the 1998 assessment enabled us to identify the features of the repository system that are most important to performance. This, in turn, allowed us to more narrowly define the additional information we need

from site investigations and laboratory studies in order to reduce levels of uncertainty about those features and to modify the design of engineered barriers to compensate for any remaining uncertainties.

To ensure that our methods of data collection, analysis, and interpretation are sound, we continued to use expert elicitations and formal peer reviews. Independent experts critiqued our work, addressed key issues important to repository system performance, assessed uncertainties in our performance assessment models, and recommended future work to reduce them. Initial findings of the formal total system performance assessment peer review panel were considered in the total system performance assessment conducted for the viability assessment, and their subsequent findings will be factored into future performance assessments.

Excavation of a cross-drift; construction of a test facility at Busted Butte

To generate the data that performance assessment modelers and designers need, we undertook two major construction projects: excavation of a cross-drift, a 2.68-kilometer (1.67-mile) tunnel that crosses the repository block, and construction of a test facility at Busted Butte, a formation near Yucca Mountain that is continuous with the formation that underlies the proposed repository horizon. Construction was completed within the fiscal year, and testing is now under way, giving scientists direct access to host rock that is yielding valuable information.

Scientific testing

Our scientific investigations center on two questions: (1) By what pathways and mechanisms, in what quantities, and at what rates could water reach waste packages, corrode them, and transport radionuclides to the accessible



Construction at the intersection of the cross-drift and the Exploratory Studies Facility



Construction at Busted Butte

environment? (2) How will heat generated by radioactive decay of waste affect those phenomena? In Fiscal Year 1998, we pursued the first question by many means: through multiple studies within the alcoves and niches of the nearly 8-kilometer- (5-mile) long underground Exploratory Studies Facility and within the cross-drift constructed within it; at the Busted Butte testing facility; in boreholes drilled thousands of feet into the earth; and in laboratory tests using soil, rock, and water samples from the site.

We pursued the second question through a suite of thermal tests designed by DOE's National Laboratories: a large block test at Fran Ridge that examines an outcropping of the repository host rock, and a single-heater test and a drift-scale test within the Exploratory Studies Facility. These tests employ electric heaters to heat rock to temperatures above the boiling point for water so that scientists can examine changes in the rock, the behavior of moisture, and changes in water chemistry, from the start of the heat-up period through the conclusion of cool-down. Cool-down at the large-block test ended in September 1998; the single-heater test was completed in the spring of 1998. Initial data were used in the total system performance assessment for the viability assessment.

The drift-scale test, many times larger than the single-heater test, is the largest such test ever undertaken. Heaters were turned on early in Fiscal Year 1998, ahead of schedule. Boreholes totaling 3,300 meters (2 miles) in length were drilled within the walls of the drift and within an adjacent drift. From these 147 boreholes, approximately 3,820 instruments relay 5,260 separate channels of data through cables to a bank of computers housed in a Data Acquisition System Office within the drift. There, a sophisticated automated data acquisition and control system permits scientists working at remote locations to monitor data and modify test parameters. The drift will be heated for 4 years, after which it will cool



**Water infiltration experiment
within Exploratory Studies Facility**

down for 4 years. As data become available they will be used for the performance assessment modeling that will support future decisions.

Confirmation of our site model

Important validation of our understanding of the site came with confirmation of our predictions of the geologic features we would encounter in excavating the cross-drift and drilling two boreholes from the surface of the site to a depth of over 2,500 feet. Those predictions were based on our integrated three-dimensional site model, which represents hydrogeologic features within a 160-cubic-mile area, to a depth of 13,000 feet, as interpreted from data from site investigations and other sources. The model continues to improve as we incorporate new data into it.

Design and engineering

Fiscal Year 1998 brought a change in policy on repository closure. Under current NRC rules, a repository would have to remain open for at least 50 years after the start of waste emplacement, so its performance could be monitored. To allow future generations the choice of monitoring repository performance for more than 50 years, we adopted a policy that repository design not preclude keeping the facility open for 100 years, or with reasonable maintenance, up to 300 years.

Design work centered on selecting the reference design for the viability assessment; the design includes repository surface and subsurface facilities, the waste package, and other engineered barriers. As recommended by the Nuclear Waste Technical Review Board and other parties, we began planning for evaluation of major design alternatives. We also began developing comprehensive design descriptions of specific systems important to the health and safety of workers and the public. Such descriptions would be needed for a license application.

Quality assurance

With consolidation of responsibility for all quality assurance (QA) oversight functions under a single office, the Office of Quality Assurance, we realized annual savings of approximately \$4 million, enhanced the independence of QA personnel, and achieved greater consistency in the interpretation of QA program requirements. Audits to identify deficiencies and development and implementation of corrective action plans continued. Working with generators and custodians of DOE-managed nuclear materials, we helped them apply our QA requirements to activities that could affect our acceptance and disposal of their wastes.

Ensuring that total system performance assessment efforts achieve full compliance with

QA requirements received close attention. QA personnel worked with technical organizations to evaluate and enhance process controls for development and validation of models used in performance assessment. Greater traceability and transparency will build confidence in the total system performance assessment that will support a decision on site recommendation and, potentially, a license application.

External interactions

We continued interacting with the NRC to develop a shared understanding of technical issues related to repository licensing, and we continued to provide information to, and benefit from the views of, the Nuclear Waste Technical Review Board.

With restoration of congressional appropriations to affected units of local government, we resumed formal interactions with them. Nye County, the county within which the Yucca Mountain site is located, invited us to participate in planning for the drilling program it is undertaking. It will drill a series of boreholes in Amargosa Valley that will yield valuable data on the saturated zone. The County plans to use the boreholes as an early warning system that can be used to monitor groundwater if a repository is constructed at Yucca Mountain.

A 5-year cooperative agreement with the University and Community College System of Nevada provides for a program of scientific and engineering research. It is intended to generate, for the public and the Yucca Mountain Site Characterization Project, an independent body of scientific and engineering data about Yucca Mountain through collaboration among independent university and college researchers and project scientists and engineers.

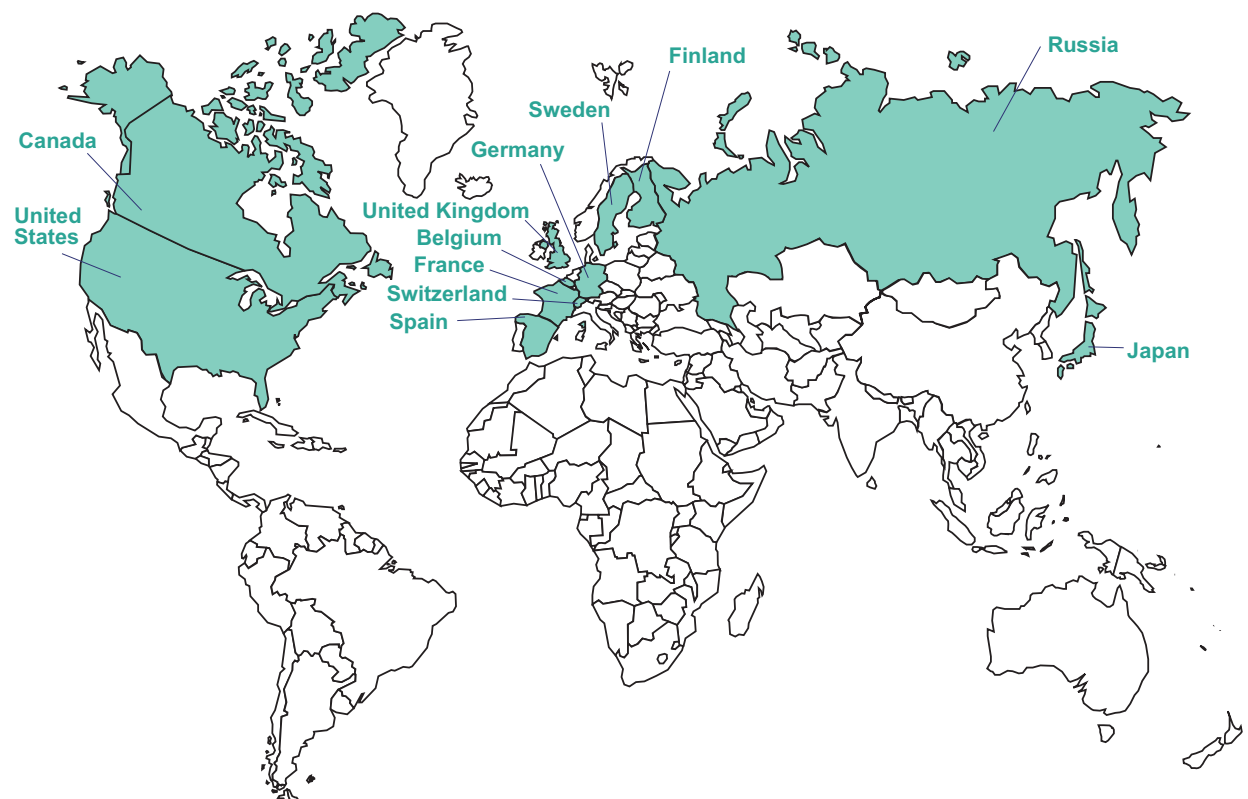
The draft environmental impact statement

An environmental impact statement (EIS) will assist the Secretary in making a decision on whether to recommend the site to the President and would accompany any Secretarial site recommendation. With the draft EIS scheduled for release for public comment in Fiscal Year 1999, we wrote preliminary chapters, conducted additional studies to analyze potential impacts identified in scoping hearings, and briefed external parties on the process by which we are developing the statement and on our schedule. We engaged an independent contractor to perform impact analyses and help us write the EIS. That contractor evaluated and tested the models used in the viability assessment to project long-term radiological effects, as those models also support the EIS.

International efforts

In support of the U.S. geologic disposal program, OCRWM continued to pursue international efforts through existing and renewed bilateral agreements with other nations and through formal membership in international organizations. The focus of these efforts is technical work that will enhance our scientific investigations of the Yucca Mountain site.

During Fiscal Year 1998, OCRWM worked with Russian officials toward formalizing a cooperative agreement for the exchange of information and technology in the area of radioactive waste management. In a September 1998 meeting, OCRWM and Russian officials agreed to develop a bilateral agreement for carrying out this work. It



Nations with significant investments in high-level radioactive waste management programs

is expected that pooling Russian and U.S. technical expertise will directly benefit both OCRWM's site characterization program at Yucca Mountain and Russia's repository initiative.

OCRWM was instrumental in the decision of the Nuclear Energy Agency of the Organization for Economic Cooperation and Development to conduct an international review of progress in high-level waste disposal. The resulting document, to be completed in 1999, will show that, even with temporary setbacks in some programs, the international consensus on geologic disposal as the preferred means of dealing with high-level radioactive waste is intact.

Acceptance, Transportation, and Integration Project

Integrating DOE-managed nuclear materials into our Program

Under current planning assumptions, a geologic repository will house commercial spent nuclear fuel (including mixed oxide spent nuclear fuel resulting from disposition of surplus weapons-usable plutonium), DOE and naval spent nuclear fuel, high-level radioactive waste, and immobilized plutonium waste forms. A notable achievement in Fiscal Year 1998 was execution of two memoranda of agreement: one with DOE's Office of Environmental Management; one with the Office of Nuclear Energy's Naval Nuclear Propulsion Program.

These memoranda, developed through years of close coordination, define in detail each party's responsibilities for a broad range of managerial, procedural, technical, and financial matters. Among the most important provisions are requirements that these parties pay their fair share of the costs of disposal and that fees be paid in full prior to the start of disposal services. Other provisions require development of a waste-acceptance process that will include waste-

acceptance criteria and a schedule for OCRWM's acceptance of DOE-managed spent nuclear fuel and high-level radioactive waste. Still other provisions require formalization of priorities for transportation activities. The memoranda are posted on OCRWM's Web site.

In Fiscal Year 1998, provisions for disposal of immobilized plutonium waste forms resulting from disposition of surplus weapons-usable plutonium were incorporated into the program baseline, which had previously been revised to incorporate DOE-owned and naval spent nuclear fuel. All DOE-managed nuclear materials were considered in the total system performance assessment conducted for the viability assessment and in analyses conducted for the draft environmental impact statement.

In addition to coordinating with the generators and owners of these materials on quality assurance efforts, we conferred with them on development of the environmental impact statement for a proposed repository at Yucca Mountain and on planning to meet safeguards and security requirements. We also acquired data from them about their waste forms. With the Office of Environmental Management's National Spent Nuclear Fuel Program, we worked to develop specifications for a suite of standardized canisters. DOE sites can use these specifications to design and fabricate the canisters they would need to ship all DOE and naval spent nuclear fuel to a repository. Providing DOE sites with this guidance now equips them to prepare more efficiently for near-term storage and eventual shipping, and it ensures a compatible interface with repository operations. At a repository, standardization would simplify waste receipt and handling operations, thus reducing the potential for worker exposure to radiation and reducing operating costs.

Waste acceptance and transportation

Reduced funding and cuts in personnel led us to defer further development of a Request for Proposals for regional service contractors who would provide waste acceptance and transportation services. Also deferred was further development of policy and procedures to implement Section 180(c) of the Nuclear Waste Policy Act, which provides for funding and technical assistance for routine and emergency response along transportation routes.

Program Management and Administration

OCRWM's *Program Plan, Revision 2*, issued in July 1998, essentially confirmed that the Program is on a sound course and making steady progress toward its goals. Issuance of the *Strategic System Management Policy* established requirements for management system processes necessary to manage the Program and implement the *Program Plan*. These requirements promote accountability while allowing managers the flexibility they need to meet program goals.

Our Fiscal Year 1998 appropriation of \$346 million was \$34 million less than the Administration's request and \$36 million less than the 1997 appropriation. The conference report that accompanied the previous year's Energy and Water Development Appropriations Act had directed us to allocate 85 percent of that year's funding to the Yucca Mountain Site Characterization Project, and in Fiscal Year 1998, we chose to do so again. The remaining 15 percent was used for waste acceptance, storage, and transportation activities, which received 2 percent, and program management, which received 13 percent.

By the end of the Fiscal Year, our Federal staff numbered 168 full-time-equivalent employees, 99 of whom were assigned to the Yucca Mountain Site Characterization Project.

Reorganization of our Program

The convergence of numerous factors resulted in the need to refocus our organization: completion of the viability assessment, the shift to a product-based approach to the work ahead, the need to bolster the resources of the Yucca Mountain Site Characterization Project, and reduction in our staffing levels. Because the Yucca Mountain Site Characterization Project expends the bulk of program funds and performs most technical work, we transferred a majority of contract management activities from headquarters to the Project. At headquarters, we eliminated two divisions and realigned another to link program integration functions more closely to planning for waste acceptance. At the Yucca Mountain Site Characterization Office, we organized all work around an Office of Licensing and Regulatory Compliance, an Office of Project Execution, and an Office of Project Support.

Contractor oversight

We also shifted responsibility for oversight and direction of our management and operating contractor to the Yucca Mountain Site Characterization Project, where most of the contractor's work is performed. We continued to implement the Department's contract-reform initiatives, working with the contractor to develop a performance-based evaluation management plan as the basis for assessing performance and determining award-fee payments.

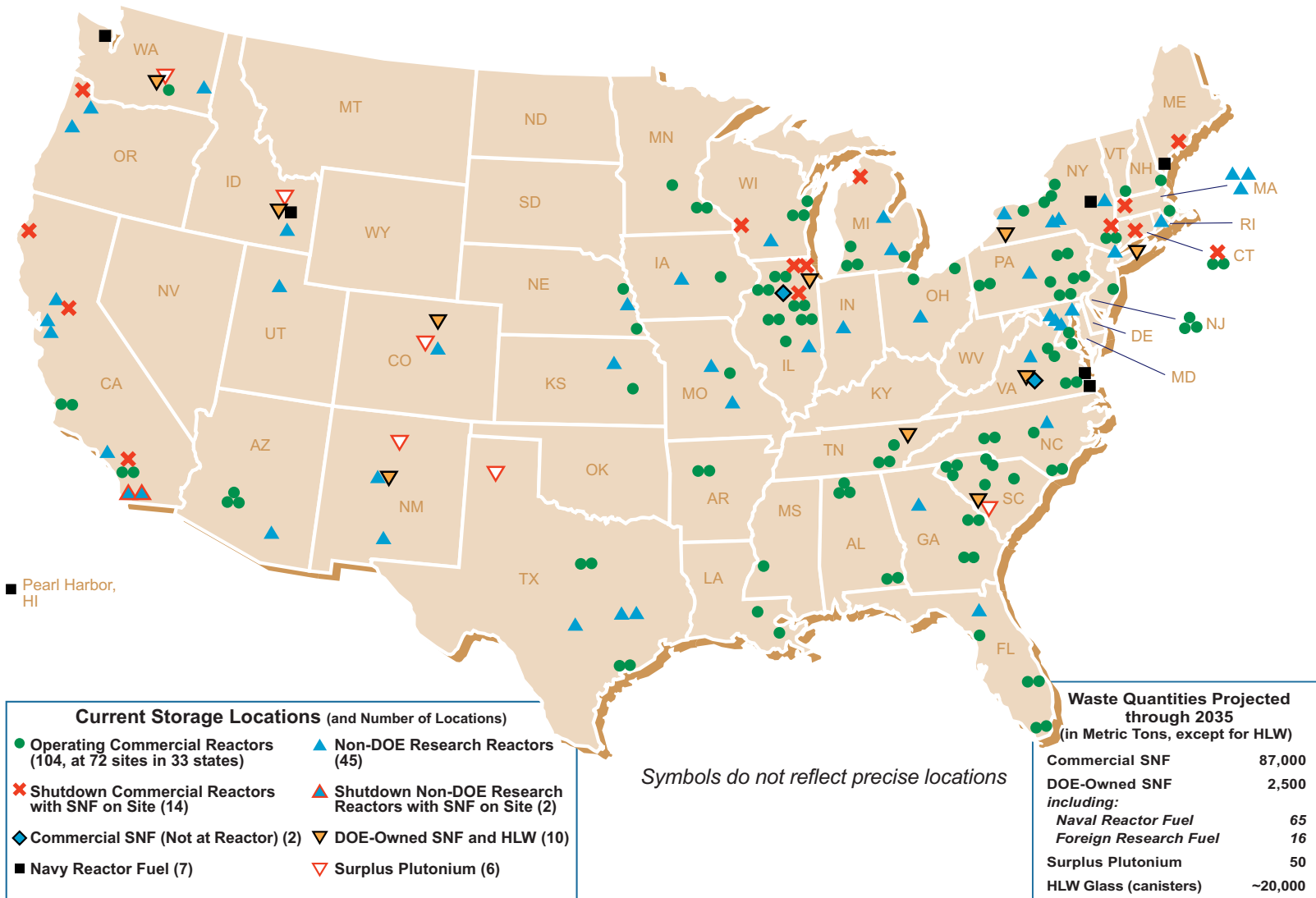
While our safety record has been outstanding, another major DOE-wide initiative—an integrated safety management system—promises to significantly strengthen safety practices from top to bottom within every organization engaged in the Yucca Mountain Site Characterization Project, including all contractor and subcontractor organizations. We began to implement this system in Fiscal Year 1998.

Information management and Y2K compliance

OCRWM continued to be recognized as a leader within the Department in the application of information technology. Toward implementation of the Web-based licensing support network planned by the NRC, we continued to convert hundreds of thousands of records to the digital format that can be accessed through the system.

Since Fiscal Year 1997, we have been working to upgrade systems and networks with Y2K-compliant hardware and software. We declared four systems mission-critical; several others were

designated important to the Yucca Mountain Site Characterization Project. During Fiscal Year 1998, we began to assess and test all software applications. OCRWM's Acting Director personally monitored progress through weekly reports and periodic videoconferences with the Yucca Mountain Site Characterization Office. We completed validation and implementation of our mission-critical systems ahead of the Department's stretch goal of January 31, 1999, and we expect to validate and implement all other systems in Fiscal Year 1999.



As of April 6, 1999

Locations of commercial spent nuclear fuel and DOE-managed nuclear materials